91602
new 82-10

ontario hydro
research division
COMPLIMENTARY COPY
Please Credit Ontario Hydro Research if
Reproduced in Whole or in Part

COLD LOAD PICKUP EXPERIENCE AT MEA UTILITIES

Report No 87-52-K

S.L. Cress
Engineer
Electrical Testing and Development Section
Electrical Research Department

ABSTRACT

A survey of MEA utilities indicated that there is a need for standard guidelines, for sizing distribution transformers and transformer fuses, which take into account cold load pickup conditions. Almost 70% of the 39 utilities responding to the questionnaire had experienced problems with cold load pickup. Present transformer and fuse sizing practices vary widely, as indicated by the fact that the 39 respondents employ at least 23 different guidelines. Only 15% of the respondents use transformer sizing guidelines that consider cold load pickup. An IBM PC computer program has been developed by Ontario Hydro Research under contract to CEA to determine acceptable transformer loading, including consideration of cold load pickup conditions. This program could be used, along with existing data, to produce a set of standard transformer loading guidelines.

job	file	date	report no.
14-401-10540	813.8	July 16, 1987	87-52-K

TABLE OF CONTENTS

		Page
1.0	INTRODUCTION	1
2.0	LOAD INFORMATION	3
3.0	PRESENT TRANSFORMER SIZING PRACTICES	5
4.0	PRESENT FUSE SIZING PRACTICES	7
5.0	OUTAGE INFORMATION	8
6.0	PROBLEMS WITH CLPU	8
7.0	FUTURE TRANSFORMER AND FUSE SIZING GUIDELINES	9
8.0	CONCLUSIONS	10
	REFERENCES	12
	APPENDIX 1 QUESTIONNAIRE WITH A SUMMARY OF RESPONSES	13
	APPENDIX 2 TRANSFORMER SIZING GUIDELINES FROM SEVERAL UTILITIES	24

ontario hydro
research division

To Dr. D. Mills
Director of Research

COLD LOAD PICKUP EXPERIENCE AT MEA UTILITIES

S.L. Cress

1.0 INTRODUCTION

Cold load pickup refers to the temporary overload that occurs when load is restored to a distribution system after a prolonged outage. This overload is caused by the loss of diversity among customer appliances when the power is restored. A distribution transformer with a large proportion of electric heating load can experience particularly severe cold load pickup conditions.

Cold load pickup (CLPU) should be taken into account when sizing distribution transformers and their fuses, in order to avoid damage to these components and unnecessary outages. In choosing the appropriate size of transformer for any installation it is necessary to know, among other factors, the magnitude and duration of the cold load pickup load. This, of course, is dependent on the size and type of connected load, the duration of the outage, the pre-outage conditions, the ambient temperature and the amount of transformer loss-of-life that is acceptable to the utility.

A considerable amount of research has been conducted in these areas (1 to 10), however, a standard method for sizing distribution transformers, taking into account CLPU, has not been adopted by utilities (11). Similarly, a standard guideline for sizing distribution transformer fuses, taking into account CLPU, is not available.

At the request of the System Planning and Load Study Committee of the Municipal Electric Association (MEA) of Ontario (formerly the Association of Municipal Electric Utilities), a joint MEA/Ontario Hydro

Research Working Group was formed to investigate the concerns of MEA utilities regarding cold load pickup. The Working Group dealt with the following objectives:

- to determine whether MEA utilities require standard guidelines for sizing distribution transformers and fuses, taking into account cold load pickup

- to determine the desired contents and format of such guidelines, if required

- to determine the present practices and problems of MEA utilities with respect to cold load pickup effects on distribution transformers and their fuses

- ultimately, to provide transformer and fuse sizing guidelines which consider CLPU.

As part of the program to achieve these objectives, a questionnaire was distributed to selected MEA utilities. A copy of the questionnaire, with the utility responses added, is provided in Appendix 1. This report summarizes the results of the survey and includes an analysis of this information.

The survey provided data on the following subjects: the nature of loads on utility distribution transformers (see Section 2.0 of this report), present transformer sizing practices (Section 3.0), present transformer fuse sizing practices (Section 4.0), outage information (Section 5.0), problems associated with CLPU (Section 6.0) and requirements for future guidelines (Section 7.0). Highlights of the survey findings are included in Table 1 and in the following two paragraphs.

As indicated in Table 1, 39 of the 72 utilities surveyed (about 55%) responded to the questionnaire. The response from the 23 largest MEA utilities was much higher (90%). A large majority of the respondents (95%) indicated that there was a need for guidelines for sizing distribution transformers and fuses taking into account cold load pickup. Almost 100% of the respondents indicated that they would consider using standard guidelines if these were developed.

Nearly 70% of the utilities who returned the questionnaire stated that they had experienced problems directly related to picking-up cold load after an outage. The nature of these problems are further detailed in Section 5.0, but the majority experienced difficulties associated with overcurrent protection schemes.

TABLE 1
HIGHLIGHTS OF MEA COLD LOAD PICKUP SURVEY

Utilities which:	Number of Utilities	Percent of Respondents
Received the Questionnaire	72	-
Responded to Questionnaire	39	-
Felt Improved Transformer and Fuse Sizing Guidelines which take CLPU into Account are Required	37	95%
Would Consider Use of MEA/OH Guidelines for Transformer and Fuse Sizing	38	97%
Desired Pre-Calculated Tables for Sizing Distribution Transformers and Fuses	35	90%
Formally Consider CLPU in Present Transformer Loading Guidelines	6	15%
Formally Consider CLPU in Present Fuse Sizing Guidelines	18	46%
Have Experienced Problems Due to CLPU	26	67%

2.0 LOAD INFORMATION

Since it was assumed that most Ontario Utilities were winter-peaking and it is known that electric space heating loads can produce severe CLPU conditions, the load information section of the questionnaire was directed at obtaining data in these areas.

The survey showed that the majority of utilities (85%) are winter-peaking; however, it is interesting to note that about 35% of the utilities had a summer peak load that was at least 90% or more of the winter peak. It is evident that picking up load after summer outages should also be considered in any guidelines that are developed for sizing transformers.

Most utilities (95%), indicated that they have records specifying whether their customers have electric or non-electric space heating. In the majority of cases (75%), records of this type were available for 75% or more of their customers. The records were established mainly by monitoring electric heat conversions and installations of electric heat in new buildings, but about 30% of the respondent utilities had gone to the extent of surveying customers to establish the nature of their heating load. Considering those customers for which records were available, the percentage with electric heat ranged from 1 to 35% with a mean value of about 15%.

Fewer utilities, only about 50%, had available data on the specific nature of the electric space heating loads connected to their distribution transformers. The data from these utilities, summarized below in Table 2, provides some feeling for the prevalence of the various space heating loads. Baseboard heating is most widespread, followed by electric furnaces and heat pumps. Even fewer utilities, about 45%, had data on the kVA size of their customers heating loads.

TABLE 2
PREVALENCE OF ELECTRIC SPACE HEATING EQUIPMENT AMONGST MEA CUSTOMERS
(Data from 20 MEA Utilities)

Electric Heating Equipment	Percent of Electric Heat Customers Using the Equipment Indicated	
	Range	Mean
Baseboard Heaters	5 to 97%	50%
Electric Furnaces	<1 to 60%	27%
Heat Pumps	<1 to 60%	11%
Plenum Heaters	0 to 10%	1%
Hydronic, Ceiling Cable, Boilers	<1 to 30%	5%

3.0 PRESENT TRANSFORMER SIZING PRACTICES

Guidelines for choosing the correct size of transformer for a particular application exist in several forms at the various MEA utilities. Table 3 shows the types of guidelines that are used and the percentage of respondents that use them.

TABLE 3
PRESENTLY USED TRANSFORMER SIZING GUIDELINES

Description of Transformer Sizing Guideline	Percent of Respondents Using This Type of Guideline
A Fixed kVA per Customer Multiplied By the Number of Customers and a Diversity Factor *	50%
Tables Containing Average Load Per Customer, Number of Customers Per Transformer, and Transformer kVA	33%
Diversity Charts with Number of Customers and Diversified kVA Per Customer for Various Load Types	26%
Computer Programs	5%
Others Including: Calculations for Each Location, Tables Based on Service Size, Existing Billing Records, and ANSI Standard Guidelines	10%

* In some cases the diversity factor is 1.

The survey indicated that amongst 39 utilities, there are at least 23 identifiably different guidelines used to size distribution transformers.

Only 27% of the respondents indicated that they had separate guidelines for sizing distribution transformers with and without electric heating load.

About 45% of the utilities have developed their own transformer sizing practices. Another 30% have modified guidelines obtained from other

utilities. About 15% of the utilities have simply adopted the guidelines used by another utility, and the remainder either have no guidelines or are not aware of the source.

The theoretical and practical information upon which these numerous existing transformer sizing guidelines are based, varies widely. About 20% of utilities stated that their transformer sizing guidelines were based on measured data, 40% on calculations, and 13% on a combination of measurements and calculations.

Any transformer sizing guideline will contain **two basic criteria**: a prediction of the **expected load** on the transformer, and a **loading limit.** The transformer is sized so that the expected load will not exceed the loading limit. This seems straightforward; however, complications arise due to the numerous ways that each of these two basic criteria can be defined. For instance, any or all of the following might be used to express the expected load: the average load, the peak steady-state load, and/or peak momentary loads. The maximum loading limit could be based on the maximum allowable winding temperature, on a maximum acceptable loss-of-life, or on an upper limit on the cost of losses. Therefore, it is the many variations in these two basic criteria that leads to the possibility of numerous different transformer sizing guidelines. The next two paragraphs illustrate the manner in which the expected load and loading limit have been defined in the various MEA transformer sizing guidelines.

Table 4 indicates several expected loads that should be considered when choosing the appropriate size of distribution transformer. Each of the various transformer sizing guidelines used by MEA utilities consider some of these loads. The percentage of responding utilities, which employ guidelines that account for these loads, is shown in Table 4. It is notable that, only 15% of the utilities use guidelines which consider CLPU.

TABLE 4
LOADS CONSIDERED IN DISTRIBUTION TRANSFORMER SIZING GUIDELINES

Load Type	Percent of Utility Guidelines Which Consider the Specified Load Type
Average Steady State Diversified Load	- 45%
Yearly Peak Steady State Load	- 40%
Cold Load Pickup Load	- 15%
Motor Starting Load	- 10%

The values for the second criteria, that is the transformer maximum loading limit, used in the various utility guidelines are listed in Table 5.

TABLE 5
MAXIMUM LOADING LIMIT EMPLOYED IN TRANSFORMER SIZING GUIDELINES

Maximum Allowable Load (% of Rated kVA)	Percent of Utilities Using the Loading Limits Indicated
50%	3%
80%	6%
100%	15%
110%	8%
120%	10%
125%	5%
130%	3%
140%	8%
150%	13%
160%	3%

Some of the utilities attached the guidelines that they employ to their returned questionnaire. Several examples are included in Appendix 2 of this report to illustrate some of the different methods for choosing the appropriate size of distribution transformer. These examples, in their present form, may prove useful for those utilities which have no guidelines. The tables at the end of Appendix 2.3, prepared by Ottawa Hydro, compare the transformer sizing guidelines of three utilities, and are particularly useful in illustrating the need for a standard approach.

4.0 PRESENT FUSE SIZING PRACTICES

Almost 100% of the respondents indicated that their transformer fuse sizing guidelines were in the form of tables that indicate the transformer kVA and the appropriate fuse rating. Only 46% of the utilities indicated that CLPU had been considered in the development of these fusing guidelines. Of these, only 20% used different factors to account for CLPU due to electrically and non-electrically heated loads.

The method used most often by utilities to account for CLPU when sizing fuses requires that a fuse withstand 2 to 3 times the normal load current for several minutes. About 44% of utilities used this technique. Another method involved assuring that the fuse minimum melt curve lay to the right of three pre-defined points. These points are: 6 x pre-outage current at 1s, 3 x pre-outage current at 10s, and 2 x pre-outage current at 5 or 15 minutes. About 15% of the respondents used this method to account for CLPU in fuse sizing.

5.0 OUTAGE INFORMATION

Outage information was requested from the utilities in order to have this data available when developing transformer and fuse sizing guidelines which consider CLPU. The lengths of outages are a major factor in determining the magnitude and duration of the CLPU overcurrents. Table 6 is a summary of the outage data supplied by 29 utilities.

TABLE 6
OUTAGE DURATION INFORMATION

DURATION	PERCENTAGE OF A UTILITY'S TOTAL OUTAGES	
	Range	Mean
1 - 15 min	0 to 95%	25%
15 - 30 min	2 to 90%	17%
30 - 60 min	2 to 100%	29%
> 60 min	1 to 80%	27%

It is evident that there is a great deal of difference in typical outage times from one utility to another, and that any universally applicable guideline must account for outages in each of the above categories, with no outage duration being particularly more likely than any other.

6.0 PROBLEMS WITH CLPU

About 67% of the responding utilities indicated that they had experienced problems on their systems that could be directly related to CLPU. Table 7 indicates the nature of the problems that were experienced and the percentage of respondents that experienced these problems. About 38% of the utilities indicated that they expected similar problems in the future.

TABLE 7
PROBLEMS EXPERIENCED BY MEA UTILITIES RELATED TO CLPU

Nature of Problem	Percentage of Utilities That Have Experienced The Problems
Sectionalizing Required after Outages	56%
Necessity to By-pass Protection During Restoration	31%
Fuse Blowing During Restoration	49%
Voltage Drop During Restoration	13%
Secondary Conductor Damage	3%
Damage to Connectors	5%
Reduction of Transformer Life	8%

7.0 FUTURE TRANSFORMER AND FUSE SIZING GUIDELINES

The respondents virtually all (95%) felt that there was a need for a standard set of guidelines for sizing distribution transformers and their fuses. Almost 100% indicated that they would consider the use of guidelines developed by the MEA and Ontario Hydro.

About 90% of the utilities felt that guidelines in the form of pre-calculated tables would be of use to them. About 70% indicated that technical data would also be useful, and 56% felt that a computer program would be useful. Approximately 85% of the respondents were in favour of guidelines that did not require the knowledge of the exact type and size of every customer's electric heating installation. Only 28% indicated that they would be willing to obtain this information from their customers, if it was required in order to apply the transformer sizing guideline.

Ontario Hydro, under contract to the Canadian Electrical Association, (Project #161 D 456) has developed a computer program for the IBM PC that could be used to develop transformer sizing guidelines. The program calculates the annual loss-of-life of a distribution transformer due to the load profile specified by the user. The program could be

employed to choose the appropriate size of transformer for any given application in such a way that the transformer does not suffer unacceptable loss-of-life. It will also indicate whether the load on the transformer will cause the internal temperature to rise above an acceptable limit. In its deterministic mode, the program utilizes the ANSI C57.91 calculation procedure to determine transformer loss-of-life per day. In its statistical mode, the program uses a novel approach to calculate a probability distribution of the transformer loss-of-life per year. The program will accept any daily or monthly load profile, and therefore can consider the load profile which occurs under CLPU circumstances. The program, along with existing data, could be used to generate tables showing the number and type of customers that could be supplied from a given size transformer.

8.0 CONCLUSIONS

1. The survey of MEA utilities has indicated that there is a distinct need for standard guidelines, for sizing distribution transformers and transformer fuses, which will take into account cold load pickup conditions. Virtually 100% of the respondents to the questionnaire felt such improved guidelines were required and would consider using guidelines developed by Ontario Hydro and the MEA.

2. The most desired format for such guidelines is a set of pre-calculated tables indicating the number of customers, of specified heating types, that can be accommodated by a transformer of a given rating. A substantial number of utilities are interested in the technical data used to derive such tables, and in a computer program to calculate this information.

3. A computer program for the IBM PC has been developed by Ontario Hydro under contract to CEA. The program calculates transformer loss-of-life due to any given loading conditions. This program could be used to produce a set of tables specifying the number and type of customers allowed on distribution transformers of various ratings.

4. Present practices for sizing distribution transformers vary widely from one utility to another, as evidenced by the fact that the 39 respondents employed at least 23 identifiably different guidelines. Only 18% of these accounted for CLPU effects. Several examples of these guidelines are attached to this report and these may be useful to some utilities until a standard guideline is developed.

5. Almost 70% of the 39 MEA utilities responding to the CLPU questionnaire had experienced problems with CLPU on their systems.

The most prevalent problems were: the requirement to sectionalize during restoration, the need to by-pass protection, the blowing of fuses and a drop in system voltage during restoration.

6. The survey provided technical information on the prevalence of various types of electric space heating equipment, the availability of load information to utility engineers, CLPU concerns of summer peaking utilities, and outages durations. All of this data will be of use in the development of transformer and fuse sizing guidelines.

Approved by:

for A.F. Baljet
Manager
Electrical Research Dept

Submitted by:

S.L. Cress
Engineer
Electrical Testing
& Development Section

SLC:kk

REFERENCES

1. American National Standards Institute, C57.91, Guide for Loading Mineral-Oil-Immersed Overhead and Padmounted Distribution Transformers, 1981.

2. Wilde, R.L., Cold Load Pickup Problems Relating to Distribution Transformers, Canadian Electrical Association Report # RP77-46.

3. Davall, P.W. and Wilde, R.L., Load Characteristics and Diversity During System Peak Day, Canadian Electrical Association Report # 065-D-100, Stage 1 - July 1980, Stage 2 - December 1984.

4. Kropp, C.F., Cold Load Pickup with Particular Reference to Residential Electric Heating, Canadian Electrical Association Position Paper, SD-176/SD-177, September 1982.

5. Yuill, G.K., Simulation of Electric Heating and Other Loads, Canadian Electrical Association Report # 171-D-296, December 1983.

6. Wilde, R.L., Effects of Cold Load Pickup at the Distribution Substation Transformer, Transactions on Power Apparatus and Systems, Vol PAS-104, No 3, March 1985.

7. Burke, J.J. and Lawrence, D.J., Characteristics of Fault In-rush and Cold Load Pickup on Distribution Systems. Paper presented to the Pennsylvania Electric Association, May 10, 1983.

8. Yeung, G.A. and Walker, D., Transformer Testing Under Cold Load Pickup Conditions, Canadian Electrical Association Report # 77-46, December 1983.

9. Buchan, P.G. and Green, M.A., Thermal Behavior of Hot Spots in Distribution Transformers, Canadian Electrical Association Report # 103-D-202, May 1984.

10. Wilde, R.L., The Effects of Cold Load Pickup on Distribution Transformers, IEEE Transactions on Power Apparatus and Systems, Vol PAS-100, No 5, May 1981.

11. Wilde, R.L., Cold Load Pickup on the Distribution System, Canadian Electrical Association State of the Art Study # 176-D-366, December 8, 1983.

APPENDIX 1

QUESTIONNAIRE WITH A SUMMARY OF RESPONSES

AMEU QUESTIONNAIRE ON COLD LOAD PICKUP

1. Objective of Survey

The objectives of this survey of Ontario Municipal Electric Utilities are to obtain information on the present practices and problems associated with picking-up cold load after extended outages, and to determine utility requirements for guidelines on this subject. Since picking-up electric heating load is likely to be most critical, the survey deals mainly with this aspect.

Most of the questions require a simple yes or no answer. Please circle the answer or fill in the blank where appropriate. It is realized that some of the information requested may not be readily available at some utilities. Where necessary, please provide approximate answers. If this is not possible, please write NA to indicate that the information is Not Available.

2.0 Load Information

2.1	Does your utility have records specifying whether customers have electric or non-electric space heating?	37 YES, 2 NO
2.2	Are these records available for:	
	a) 75% to 100% of your customers?	27 YES, 8 NO, 4 NA
	b) 50% to 74% of your customers?	33 YES, 2 NO, 4 NA
	c) 25% to 49% of your customers?	34 YES, 1 NO, 4 NA
	d) 0% to 24% of your customers?	35 YES, 0 NO, 4 NA
2.3	Have these records been established by:	
	a) recording non-electric to electric heat conversions in existing areas?	35 YES, 2 NO, 2 NA
	b) recording new electric heat installations?	35 YES, 2 NO, 2 NA
	c) surveying customers?	11 YES, 12 NO, 16 NA
	d) another method? Please specify._____	8 YES, 5 NO, 26 NA
2.4	Considering those customers for which records are available, what percentage of them have electric space heating?	1 to 35% Mean Value 15%

2.5 Do your records indicate the kVA size of a customer's electric heating load? **17 YES, 21 NO, 1 NA**

2.6 Where records are available, do they indicate whether a customer with electric space heating has:

a)	an electric furnace?	**22 YES, 16 NO, 1 NA**
b)	a heat pump?	**23 YES, 15 NO, 1 NA**
c)	baseboard heaters?	**23 YES, 15 NO, 1 NA**
d)	plenum heaters?	**20 YES, 17 NO, 2 NA**
e)	other heating equipment?	**11 YES, 17 NO, 11 NA**
	Please specify type.	**Hydronic, ceiling cable, boilers**

2.7 What percentage of your customers with electric heating have:

		Range	Mean
a)	electric furnaces?	<1 to 60%	27
b)	heat pumps?	<1 to 60%	11
c)	baseboard heaters?	5 to 97%	50
d)	plenum heaters?	0 to 10%	1
e)	other heating equipment?	<1 to 30%	5
	Please specify type.	Hydronic, ceiling cable, boilers	

2.8 What is the highest saturation of electrically heated residences connected to a distribution transformer on your system (in percent of total number of residence connected)?

30 @ 100%
1 @ 30%
1 @ 25%
1 @ 15%
6 NA

2.9 Does your utility have predictions for the growth of electric heating load,

a)	in existing residential areas?	**9 YES, 30 NO**
	If yes, please specify predicted growth.	**0.5 to 3% per year**
b)	in new residential areas?	**9 YES, 30 NO**
	If yes, please specify predicted growth.	**0.5 to 8% per year**

2.10 What is the overall predicted load growth for your system due to all causes? **0.6 to 9% per year**

2.11 Does your utility's highest peak load occur in the winter? **32 YES, 7 NO**

2.12 Please specify winter peak load. **1.6-1452 MW in 84/85**

2.13 Please specify summer peak load. **0.8-1346 MW in 84**

2.14 Please specify the amount of each of the following load types that are present on your system.

0 to 65% Industrial
7 to 50% Commercial
20 to 80% Residential

2.15 Please complete the following table:
(Numbers provided below are sums of the values submitted by all respondents)

	Feeder Voltages					
	4.2/2.4	8.3/4.8	12.5/7.2	13.8/8	25/14.4	27.6/16
Number of Distribution Transformers on your System	104,200	10,625	14,800	39,120	3500	19,535
Number of Customers on your System	687,530	59,450	66,000	286,780	14,500	216,090

3.0 Present Design Practices for Sizing Distribution Transformers

3.1 In what form are your utility's present guidelines for choosing the appropriate size of distribution transformers for an application?

a) tables containing average load per customer, number of customers per transformer, and transformer kVA — **13 YES, 16 NO, 10 NA**

b) diversity charts indicating number of customers and diversified kVA per customer for a given load type — **10 YES, 17 NO, 12 NA**

c) a fixed kVA per household multiplied by the number of households and a diversity factor — **20 YES, 12 NO, 7 NA**

d) computer programs — **2 YES, 20 NO, 17 NA**

e) other, please specify — **4 YES, 16 NO, 19 NA**

Calculation chart, use of billing records, based on service size, ANSI Standard

3.2	Could these guidelines be made available to the AMEU? If possible, please attach a copy.	14 YES, 13 NO, 12 NA
3.3	In what year was the latest fundamental revision of your utility guidelines for sizing distribution transformers?	1974 to 1984
3.4	Were these guidelines:	
	a) developed by your utility?	28 YES, 4 NO, 7 NA
	b) adopted from the practices of other utilities?	17 YES, 4 NO, 18 NA
	c) recommended by a manufacturer?	1 YES, 15 NO, 23 NA
	d) from another source? Please specify.	4 YES, 12 NO, 23 NA 1982 CEA Report, Experience with CSP trips
3.5	Are these guidelines:	
	a) based on measured demand and density data?	13 YES, 10 NO, 16 NA
	b) based on theoretically predicated demand and diversity data?	21 YES, 8 NO, 10 NA
3.6	Were the following loads considered in establishing the transformer sizing guidelines employed by your utility?	
	a) average steady-state diversified load	18 YES, 10 NO, 11 NA
	b) yearly peak steady-state load	16 YES, 13 NO, 10 NA
	c) emergency undiversified load picked-up after an extended outage (cold-load pick-up)	6 YES, 20 NO, 13 NA
	d) momentary high currents due to start-up of secondary loads	6 YES, 19 NO, 14 NA

3.7	If cold load pick-up is accounted for in your prediction of expected load on a transformer, is it considered by a simple multiplication factor times the pre-outage load?	3 YES, 20 NO, 16 NA
	If yes, please specify the cold load pick-up factor you employ.	1.2 to 2 times the pre-outage current
3.8	If cold load pick-up (CLPU) is considered in sizing distribution transformers, what is the basis for the CLPU factor?	
	a) past experience	4 YES, 6 NO, 29 NA
	b) adopted practices of other utilities	2 YES, 8 NO, 29 NA
	c) recent CEA publications on CLPU	3 YES, 9 NO, 27 NA
	d) other publications, please specify	3 YES, 9 NO, 27 NA Ottawa Hydro documents
3.9	Have any studies of CLPU as related to distribution transformer sizing been conducted at your utility?	2 YES, 35 NO, 2 NA
	If yes, please indicate title and author.	
3.10	Do your guidelines for sizing distribution transformers differentiate between transformers that have electric heating loads and those that do not?	27 YES, 8 NO, 4 NA

3.11 Do your guidelines size transformers so that:

a) the expected load will not exceed a certain percentage of transformer-rated kVA? **29 YES, 4 NO, 6 NA**
If yes, what is your maximum allowable load on a transformer in percent of rated transformer kVA? **Yearly 50% to 150%, Summer only 110%, Winter only 140% to 160%**

b) expected load will not cause transformer temperature to rise above a certain temperature limit? **5 YES, 22 NO, 12 NA**

If yes, what is your transformer temperature limit in ^{o}C? **105^{o}C to 110^{o}C**

c) expected load will not cause an insulation life loss of more than a specified value? **3 YES, 23 NO, 13 NA**

If yes, what is your maximum allowable loss of insulation life? **0% of normal life**

4.0 Present Design Practices for <u>Sizing Distribution Transformer Fuses</u>

4.1 In what form are your present guidelines for sizing distribution transformer fuses?

a) tables indicating transformer kVA and fuse size **38 YES, 0 NO, 1 NA**

b) computer programs **0 YES, 18 NO, 21 NA**

c) other, please specify **2 YES, 13 NO, 24 NA**
Fuse co-ordination studies

4.2 Do these guidelines consider CLPU? **18 YES, 17 NO, 5 NA**

4.3 If CLPU is considered, is there differentiation between CLPU for electrically and non-electrically heated customers? **4 YES, 18 NO, 17 NA**

4.4 If CLPU is considered, what is the basis for the CLPU factor?

a)	past experience	10 YES, 5 NO, 24 NA
b)	adopted practices of other utilities	9 YES, 7 NO, 23 NA
c)	manufacturer recommendations	6 YES, 8 NO, 25 NA
d)	recent CEA publications on CLPU	2 YES, 10 NO, 27 NA
e)	other publications, please specify	0 YES, 2 NO, 37 NA

4.5 Are any of the following practices employed to account for CLPU in choosing distribution transformer fuse sizes?

a)	fuse minimum melting curve must lie to the right of the following points: 6 x Pre-outage current @ 1 s 3 x Pre-outage current @ 10 s 2 x Pre-outage current @ 5 min or 15 min	6 YES, 16 NO, 17 NA
b)	fuse minimum melting curve must lie to the left of 1.3 times the maximum allowable diversified load	6 YES, 16 NO, 17 NA
c)	fuse must withstand 2 to 3 times normal load current for several minutes	17 YES, 7 NO, 15 NA

5.0 Outage Information

5.1 Are statistics on extended outages kept routinely at your utility? 21 YES, 17 NO, 1 NA

5.2 In what form?

a)	computerized outage data	3 YES, 17 NO, 19 NA

b) tabulated data — **13 YES, 12 NO, 14 NA**

c) other format, please specify — **7 YES, 11 NO, 21 NA**
Daily log of interruptions, file of outage reports.

5.3 On a system basis, please indicate the percentage of outages per year which fall into the following duration categories:

	Outage Duration			
	1-15 min	15-30 min	30-60 min	>60 min
Percentage of outages per year - Range	0%-95%	2%-90%	2%-100%	1%-80%
- Mean	25%	17%	29%	27%

6.0 Problems Associated with CLPU

6.1 Has your utility experienced any problems that can be directly related to CLPU? — **26 YES, 13 NO**

6.2 If yes, have these problems included any of the following?

a) sectionalizing required to pick up load after an outage — **22 YES, 4 NO, 13 NA**

b) necessity to by-pass protection when restoring load — **13 YES, 9 NO, 17 NA**

c) fuse blowing during restoration — **19 YES, 5 NO, 15 NA**

d) voltage drop along feeder during restoration (motors do not start, etc) — **5 YES, 15 NO, 19 NA**

e) secondary conductors damaged or sag — **1 YES, 19 NO, 19 NA**

f) connectors damaged — 2 YES, 19 NO, 18 NA

g) transformer life reduced — 4 YES, 11 NO, 24 NA

h) other, please specify — 1 YES, 9 NO, 29 NA
Overloaded cable

6.3 Are these problems anticipated in the future of any locations — 15 YES, 15 NO, 9 NA

Which ones? — 7-a, 4-b, 6-c, 1-d, 2-e, 1-f, 3-g

7.0 Guidelines for Sizing Distribution Transformers

7.1 Does your utility consider that there is a need for improved guidelines for sizing distribution transformers that will take into account CLPU of electric heating loads? — 37 YES, 0 NO, 2 NA

7.2 Would your utility consider adopting CLPU guidelines developed by the AMEU/Ontario Hydro committee — 38 YES, 0 NO, 1 NA

7.3 If no, please indicate the reason: _____

7.4 Which of the following would be of use to your utility for sizing distribution transformers and fuses?

a) technical data from which specific guidelines could be developed by your utility — 27 YES, 2 NO, 10 NA

b) computer programs to allow your utility to develop its own guidelines — 22 YES, 3 NO, 14 NA

c) pre-calculated tables or charts indicating transformer and fuse sizes for various types of customer loads — 35 YES, 1 NO, 3 NA

d) other, please specify — Temperature stickers

7.5 If information on the specific types and size of electric heating employed by each customer was necessary in order to apply distribution transformer loading guidelines, would your utility:

a) undertake to gather this data for each transformer installation? **11 YES, 16 NO, 12 NA**

b) seek a more general guideline for sizing transformers? **33 YES, 3 NO, 3 NA**

8.0 Contacts

8.1 For further information on this subject, who may we contact at your utility?

Name: _____

Position: _____

Address: _____

Telephone number: _____

8.2 Please return response to:
Mr. Stephen L. Cress
Ontario Hydro Research Div
800 Kipling Avenue,KL206
Toronto, Ontario, M8Z 5S4
(416) 231-4111 Ext 6557

APPENDIX 2

TRANSFORMER SIZING GUIDELINES FROM SEVERAL UTILITIES

APPENDIX 2.1

TRANSFORMER SIZING GUIDELINES
PREPARED BY HYDRO MISSISSAUGA

TRANSFORMER SIZING FOR GENERAL SERVICE CUSTOMER

TRANSFORMER SIZING SUMMARY

PROJECT LOCATION: ALKARIL CHEMICALS
3265 WOLFEDALE RD

WORK ORDER NUMBER: 5570-1

CONSUMER DATA BASE:

› FROM THE CONSUMER DATA BASE WORK SHEET, ENTER THE EXPECTED KW DEMAND..... 658 KW

› FROM THE CONSUMER DATA SHEET ENTER THE SERVICE ENTRANCE SIZE AMPS AND KW ..... 1600 A

1600 KW

TRANSFORMER LOADING GUIDE:

›ENTER THE RELEVENT DETAILS REGARDING THE TRANSFORMER LOADING. THESE DETAILS TO BE OUTLINED ON THE TX. LOADING WORKSHEET:

› WINTER___ SUMMER X
› ESTIMATED LOAD DURATION: 8 HOURS
› RECOMMENDED MAXIMUM OVERLOAD: 5 % (O/L RATING)
› SPECULATIVE BLDG.____
› SPECIAL:_____

REFERENCE LOADING DATA:

› USING THE SELECTED LOADING DATA BASE AS DETAILED ON THE REFERENCE LOADING DATA WORK SHEET,ENTER THE ESTIMATED LOAD FOR THIS TYPE OF INSTALLATION: 684 KW

EXPECTED KW DEMAND TO SERVICE ENTRANCE RATIO:

658 / 1600x.8 x 100% = 51 %

RECOMENDED TRANSFORMER SIZE: 3 X 250 KVA (55/65 C RISE__ 65 C RISE X)

FOR 55/65 DEGREE C RISE INCREASE TRANSFORMER KVA BY 12.5 %

EXPECTED KW DEMAND TO RECOMMENDED TRANSFORMER SIZE RATIO:

658 / 750 X 100 % = 87.7 % (LOADING RATIO)

O/L RATING - LOADING RATIO = +17.3 %

THIS PERCENTAGE MUST BE POSITIVE OTHERWISE RE-EVALUATE THE TRANSFORMER SIZE OR THE LOADING OR BOTH AS MAY BE REQUIRED.

5. All secondary cables shall be sized to accommodate peak kW demand as per EI-31 R1 with the minimum standard size being 2 - #4/0 + 1 - #2/0 Al.

6. Transformer Sizing/Loading.

   Summer and winter peak demands shall be calculated satisfying the following criteria:

   - winter peak kW ≤ 140% transformer nameplate kVA
   - winter average (24 hour) kW ≤ 115% transformer nameplate kVA
   - summer peak kW ≤ 110% transformer nameplate kVA
   - summer average (24 hour) kW ≤ 100% transformer nameplate kVA

   The following criteria are assumed in the determination of the above noted kW's:

   (a) Module size 6 - 14 units

   (b) Individual module make-up is generally one type.

   (c) Unit peak kW (non-electrically heated) is 2.8 kW of a 1000 sq.ft. or 100 sq. metre home. An addition of .085 kW is added for every 100 sq. ft. or .97 kW for every 10 sq. metres up to 3000 sq. ft. or 275 sq. metres.

   (d) Unit Δ peak kW (added to air conditioning or electric heat units) 2 kW for 1000 sq. ft. or 100 sq. metre home with an addition of 0.050 kW per 100 sq. ft. or 0.057 kW per 10 sq. metres up to 3000 sq. ft. or 275 sq. metres.

   (e) Air Conditioning (central); ∈ kW air conditioning installed or heat gain x (0.80) plus (d).

   (f) Electric Heat (central); ∈ kW electric heat installed or heat loss * x (1.0) plus (d).

   (g) Electric Heat (non-central, such as baseboard); ∈ electric heat * installed or heat loss x (0.75) plus (d).

7. In respect of Developer designed/installed projects, designs shall be altered satisfying all of the above criteria, including Ultimate Master Plans, where applicable.

8. For certain projects, we will attempt to exhaust current stock of 2 - #1/0 & 1 - #2 Al. cable during 1983.

9. Attached examples of calculations.

* Special considerations for "Low Energy" E/H units.

N.O. Tretter, P.Eng.
Design Engineer

NOT/bw
Encl.

EI-27
R8

APPENDIX 2.2

TRANSFORMER SIZING GUIDELINES
PREPARED BY ONTARIO HYDRO

TRANSFORMERS - FOR OVERHEAD DISTRIBUTION LINES

1.0 SCOPE

This Section applies to pole-mounted distribution transformers installed on Ontario Hydro overhead distribution lines or on private customer's transformer poles operating at voltages 16/27.6 kV or below.

2.0 GENERAL

The standard for single or three-phase distribution transformer installations shall be direct or bracket pole-mounted arrangements on a single pole with the primary neutral and/or secondary bus and service located below the transformers.

Where the transformer mass is beyond the structural limitation of the single pole, multi-pole structures shall be permitted.

3.0 DISTRIBUTION TRANSFORMER INSTALLATION

Pole-mounted distribution transformers on a single pole structure shall be installed in accordance with ED19-35 for single-phase installations or ED19-63.2 for three-phase installations. Platform-mounted transformer installations on a multi-pole structure shall be installed in accordance with ED19-75. Other requirements for transformer installations shall be as discussed below.

3.1 Transformer kV.A Size

The transformer size, kV.A, for residential customers (eg. homes or cottages) may be estimated in accordance with Table 1 and 2. The transformer size is based on the diversified peak demands of various types of customers. Also, in Table 1 the unit value per customer is for a detached house. For other house types, or additional add-ons such as central air conditioning, heat pump, or plenum heater, use the appropriate correction factors listed in Table 1. For other house sizes which are not listed in Table 1, interpolate between the columns for unit values.

TABLE 1
Unit Value Per Customer

Type of Customer	Unit Value Per Customer House Size*			
	90m² (1000ft²)	190m² (2000ft²)	280m² (3000ft²)	370m² (4000ft²)
Non-Elec. Heating (Gas or Oil)	1.5	2.0	2.5	3.0
Elec. Heating-Baseboard	3.0	4.0	5.0	6.0
Elec. Heating-Central	4.0	5.0	6.0	7.0
Cottage (Year-Round customer)	2.0			
Cottage (Summer customer)	1.0			
Correction Factors For				
i) Central Air, Heat Pump or Plenum Heater (Non-Elec. Cust. Only)	Add 0.5	Add 1.0	Add 1.5	Add 2.0
ii) Semi-Detached House	Multiply the appropriate Unit Value by 0.9			
iii) Town or Row-Housing	Multiply the appropriate Unit Value by 0.8			

* For other house sizes interpolate between columns for unit values.

original issue Sept. 1955

TABLE 2
Transformer kV.A Size

Total Unit Value	Transformer Size (kV.A)
1-3	10
4-9	25
10-14	37.5
15-24	50
25-36	75
37-50	100
51-88	167

Example #1:

What transformer size is required to supply 9 detached houses, where 2 houses have central electric space heating and are 140m^2 (1500ft^2), and 7 houses have gas space heating and are 190m^2 (2000ft^2) with 2 gas heated houses having central air conditioning?

STEP 1 - Calculate Unit Values with any correction factors

2 C. Elec. with 140m^2 (1500ft^2) @4.5/cust.(interpolated) = 9.0 Unit Value
5 Non-Elec.with 190m^2 (2000ft^2) @2.0/cust. = 10.0 " "
2 Non-Elec. with 190m^2 (2000ft^2) and C.Air @3.0/cust. = 6.0 " "
Total Unit Value = 25.0

STEP 2 - Select Transformer Size with the Total Unit Value

Therefore, from Table 2 for a Total Unit Value of 25 the transformer size is 75 kV.A.

Example #2:

What transformer size is required to supply 14 semi-detached houses with 140m^2 (1500ft^2) and having baseboard electric heating?

STEP 1 - Calculate Unit Values with any correction factors

For a detached house with 140m^2 (1500ft^2) and having baseboard electric heating, the unit value is 3.5 (interpolated)

For the same semi-detached house and using the correction factor of 0.9, the unit value is 3.5 x 0.9 = 3.2

14 Elec.-Baseboard with 140m^2 (1500ft^2) @3.2/cust. = 44.8

STEP 2 - Select Transformer Size with the Total Unit Value

First, round-off the Total Unit Value to 45

Therefore, from Table 2 for a Total Unit Value of 45 the transformer size is 100 kV.A.

ontario hydro

distribution engineering instruction number 68

DIVERSITY CHART FOR UNDERGROUND DISTRIBUTION SYSTEMS

INTRODUCTION

This instruction supersedes Engineering Instruction Number 68 dated April 1964 and provides updated diversity demand curves based on statistics from Ontario Hydro's load surveys covering the period from 1966 to 1972. Where extrapolation is necessary in fitting the curves, the diversity curves in the G.E. Distribution Book are used as a reference. The diversity curves will be revised when new data on diversified demand warrants changes.

PURPOSE

To provide a diversity chart for selection of transformers and cables in underground distribution systems.

DETAILS

1. Description and Basis of Curves

Curves on the chart represent diversified demand per home as a function of customer group size--i.e., the number of homes fed from a transformer. Each home is considered as a house having an area up to 1,500 square feet. Homogenous load is assumed in each group. Transformer sizing curves (#1, 2, 3) are based on diversified demand data, while cable sizing curves (A & B) are derived from overload capability of the transformer as described in Detail 2. A summary is as follows:

For Transformer Selection

Curve 1 Houses with normal electrical appliances including lighting and water heater, but without electric heat.

Curve 2 Houses same as in Curve 1 plus electric heat supplied from individually controlled room heaters.

Curve 3 Houses same as in Curve 1 plus electric heat supplied from central furnaces or heat pumps.

For Cable Selection (and Ultimate Loading of Transformers)

Curve A Similar houses to Curve 1.

Curve B Similar houses to Curve 2 or 3.

2. Loading of Transformers

Normally the peak loads will occur in the winter and the effect of a low ambient temperature in choosing transformer sizes should be taken into consideration. It is suggested that load growth within each group of customers will be supplied by the transformer overload capability. The permissible load levels for normal transformer life expectancy, based based on A.S.A. Transformer Loading Guide for an ambient temperature of 0°C, are shown below.

	Non-Electric Heated Homes	Electric Heated Homes
Equivalent Initial Preload (% of Peak)	77	93
Peak Load Duration (Hours)	3	6
Permissible Transformer Load at Peak, in % of rated kVA	161	145

3. Use of Chart (TD16813A)

(a) Determine type and size of customer group.

(b) For transformer selection, use either curve 1, 2 or 3.

(i) On the appropriate curve, locate the point corresponding to the number of homes and obtain diversified demand (kVA per home) intersecting this point.

(ii) Multiply this demand by the number of homes in the group to obtain the total diversified load for the group.

(iii) This total diversified load will indicate the nameplate kVA rating of the transformer to be selected.

(c) For cable selection, use either curve A or B.

(i) kVA per home can be obtained in the same manner as described in (b)(i).

(ii) Minimum cable size for secondary services connected directly to the transformer or secondary bus is based on kVA for a single home.

(iii) Minimum cable size for a secondary bus is based on the total diversified kVA of the number of homes connected to the bus.

(iv) Maximum demand amperes are obtained as follows: Amps = kVA/V

where kVA = the appropriate load [see (c)(ii), (c)(iii)]

V = line-to-line secondary voltage

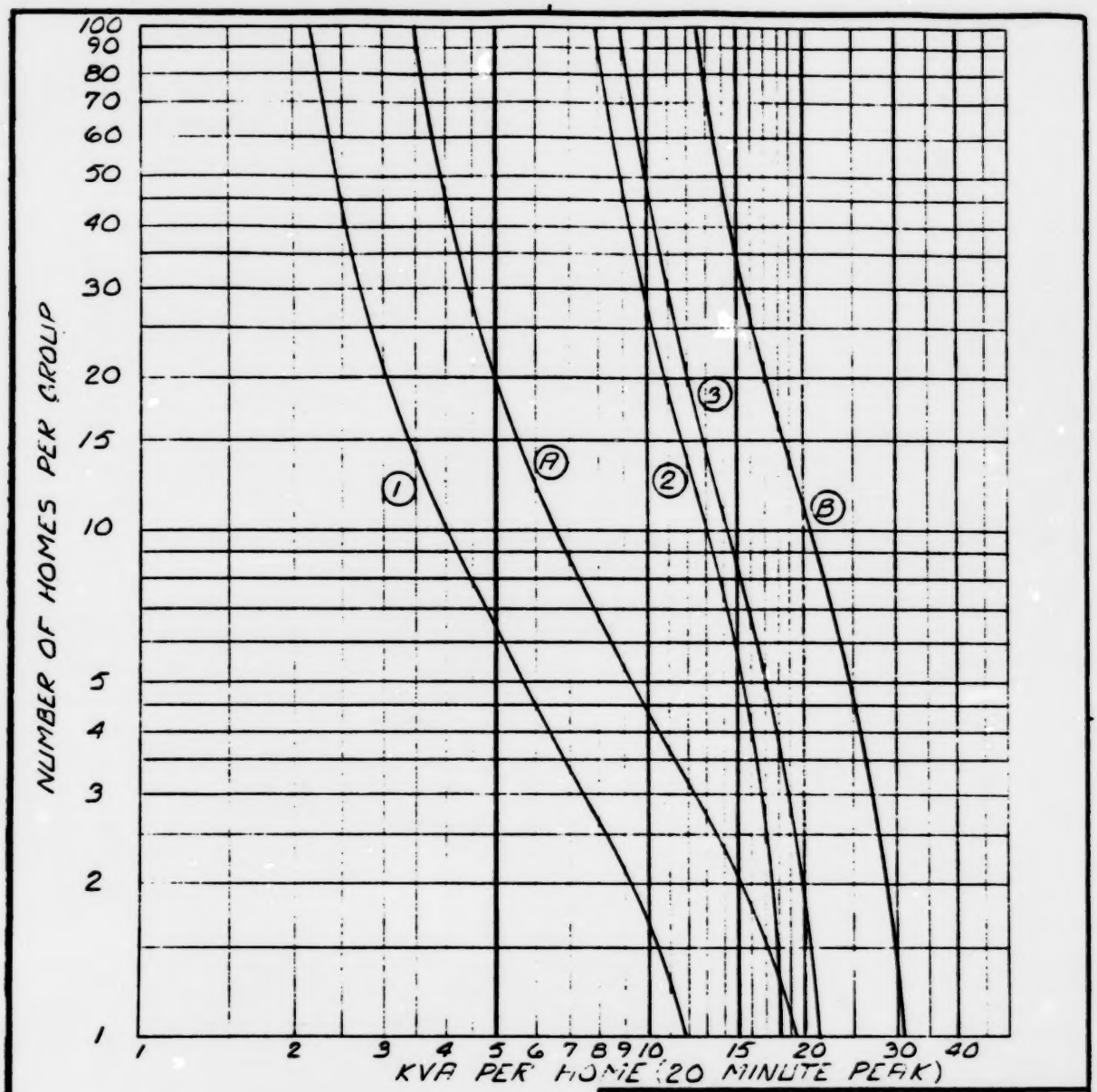
(v) After current is calculated, refer to Standards-Lines 25U and E/I 152 for selection of cables.

STATUS

This Engineering Instruction is intended as a guide for selection of transformer and cable size in distribution underground application within Ontario Hydro.

Should additional information be required, refer to Transmission and Distribution Design Department.

for R. G. Wykes
Transmission & Distribution Design Engineer



TRANSFORMER SIZING
USE CURVES 1, 2, 3

CABLE SIZING
USE CURVES A, B

DIVERSITY CHART FOR U/G DISTRIBUTION SYSTEMS

ontario hydro
transmission & distribution
projects division

work order 59984130	dsn'd L.A.	chkd'g	dwg prod supv
date APRIL 73	chkd		design engr
scale —			prod engr
ref roll number	rev no	date	procedure
dsn'd / chkd	appd	scale	dwg no TD16813A00

APPENDIX 2.3

TRANSFORMER SIZING GUIDELINES
PREPARED BY OTTAWA HYDRO
AND
COMPARISON OF OTTAWA HYDRO, ONTARIO HYDRO AND NEW BRUNSWICK HYDRO GUIDELINES
PREPARED BY OTTAWA HYDRO

SINGLE PHASE POLE MOUNTED TRANSFORMER SIZING AND EXPULSION FUSING PRACTICE

Due to the increasing penetration of electric heating loads, it is necessary to define new practices for pole mounted transformer sizing and fusing. The tables listed follow immediately.

- Suggested Fuse Sizes For Pole Mounted Transformers, 2400 Volts and 7600 Volts, Single Phase.
- Suggested Transformer Sizing, All Gas Mixed With All Electric Customers. (15 - 20 kW Furnace)
- Suggested Transformer Sizing, Fossil Heat and Electric Hot Water Mixed With All Electric Customers. (15 kW$^{+}_{-}$Heat Loss)
- Suggested Transformer Sizing, Fossil Heat and Electric Hot Water Mixed With All Electric Customers. (20 kW$^{+}_{-}$Heat Loss)
- Suggested Transformer Sizing, Fossil Heat and Electric Hot Water Mixed With All Electric Customers. (25 kW$^{+}_{-}$Heat Loss)

It is suggested that these various charts represent a good starting point. As we build up more statistics on loads, modifications may be necessary.

These suggested practices do not apply to transformers in kiosks or vaults protected by current limiting fuses. A separate instruction will be issued.

In respect to transformer changeout policy, an earlier report "Transformer Changeout and Electric Heat Conversions" dated 18 November 1981 continues to apply. A check of probable peak load, however, may be had by consulting the Charts in the Appendix.

An extensive appendix is included showing the derivation of the various tables. This should also be read as it establishes the basis for the various tables and also contains a number of comments. It is also intended as a record and background against which future changes may be measured.

It would appear that situations may arise in which a 100 kV.A transformer would be desirable, and it is suggested that consideration be given to having a number of such units available for pole mounting.

The S & C standard speed fuse link offers a minor advantage over the S & C K speed link in cold load pick-up and consideration should be given to revising our present practice.

SUGGESTED FUSE SIZES FOR POLE MOUNTED TRANSFORMERS

2400 VOLTS and 7600 VOLTS SINGLE PHASE

	2400 VOLTS		7600 VOLTS	
TRANSFORMER RATING	S & C STD SPEED TCC 123-6	S & C K SPEED TCC 165-6	S & C STD SPEED TCC 123-6	S & C K SPEED TCC 165-6
25 kVA	25	25K	7	8K
37 kVA	30	30K	10	10K
50 kVA	40	40K	15	15K
75 kVA	65	65K	20	20K

SUGGESTED TRANSFORMER SIZING

ALL GAS MIXED WITH ALL ELECTRIC (15 - 20 kW FURNACE)

NUMBER OF ELECTRIC HEAT CUSTOMERS (15 - 20 kW FURNACE)

NUMBER OF ALL GAS CUSTOMERS	0	1	2	3	4	5	6	7	8	9	10
0	-	25	25	37	50	75	75	75	100	100	100
1	25	25	37	50	50	75	75	75	100	100	100
2	25	25	37	50	75	75	75	100	100	100	
3	25	25	37	50	75	75	75	100	100	100	
4	25	25	37	50	75	75	75	100	100	100	
5	25	25	37	50	75	75	100	100	100	100	
6	25	37	50	50	75	75	100	100	100		
7	25	37	50	75	75	75	100	100	100		
8	25	37	50	75	75	75	100	100	100		
9	25	37	50	75	75	100	100	100	100		
10	25	37	50	75	75	100	100	100	100		
11	25	37	50	75	75	100	100	100			
12	25	37	50	75	75	100	100	100			
13	25	37	50	75	75	100	100	100			
14	37	50	50	75	75	100	100	100			
15	37	50	75	75	75	100	100	100			
16	37	50	75	75	75	100	100				

SUGGESTED TRANSFORMER SIZING

FOSSIL HEAT, ELECTRIC HOT WATER MIXED WITH ALL ELECTRIC

(15 kW± HEAT LOSS)

NUMBER OF ELECTRIC HEAT CUSTOMERS (1500 FT^2 HOUSE, 15 kW± HEAT LOSS)

NUMBER FOSSIL HEAT ELECTRIC HOT WATER CUSTOMERS	0	1	2	3	4	5	6	7	8	9	10
0	-	25	25	37	50	75	75	75	100	100	100
1	25	25	37	50	75	75	75	100	100	100	
2	25	25	37	50	75	75	100	100	100	100	
3	25	37	50	50	75	75	100	100	100		
4	25	37	50	75	75	75	100	100	100		
5	25	37	50	75	75	75	100	100	100		
6	25	37	50	75	75	100	100	100	100		
7	25	37	50	75	75	100	100	100			
8	25	50	50	75	75	100	100	100			
9	37	50	75	75	75	100	100	100			
10	37	50	75	75	100	100	100				
11	37	50	75	75	100	100	100				
12	37	50	75	75	100	100	100				
13	37	50	75	75	100	100	100				
14	37	50	75	75	100	100					
15	50	75	75	100	100	100					
16	50	75	75	100	100	100					

SUGGESTED TRANSFORMER SIZE
FOSSIL HEAT, ELECTRIC HOT WATER MIXED WITH ALL ELECTRIC
(20 kW^{t} HEAT COSTS)

NUMBER OF ELECTRIC HEAT CUSTOMERS (2000 FT^2 HOUSE, 20 kW^{t} HEAT LOSS)

NUMBER OF FOSSIL HEAT ELECTRIC HOT WATER CUSTOMERS	0	1	2	3	4	5	6	7	8	9
0	-	25	37	50	75	75	75	100	100	100
1	25	25	37	50	75	75	100	100	100	
2	25	37	50	75	75	100	100	100		
3	25	37	50	75	75	100	100	100		
4	25	37	50	75	75	100	100			
5	25	37	50	75	75	100	100			
6	25	50	75	75	100	100	100			
7	25	50	75	75	100	100	100			
8	37	50	75	75	100	100				
9	37	50	75	75	100	100				
10	37	50	75	75	100	100				
11	37	50	75	100	100	100				
12	37	75	75	100	100	100				
13	37	75	75	100	100					
14	37	75	75	100	100					
15	50	75	75	100	100					
16	50	75	75	100	100					

SUGGESTED TRANSFORMER SIZE
FOSSIL HEAT, ELECTRIC HOT WATER MIXED WITH ALL ELECTRIC
(25 kW± HEAT COSTS)

NUMBER OF ELECTRIC HEAT CUSTOMERS (3000 FT^2 HOUSE, 25 kW± HEAT LOSS)

NUMBER OF FOSSIL HEAT ELECTRIC HOT WATER CUSTOMERS	0	1	2	3	4	5	6	7
0	-	25	37	75	75	100	100	100
1	25	37	50	75	75	100	100	
2	25	37	50	75	100	100		
3	25	37	75	75	100	100		
4	25	50	75	75	100	100		
5	25	50	75	75	100	100		
6	25	50	75	75	100			
7	25	50	75	100	100			
8	37	50	75	100	100			
9	37	50	75	100	100			
10	37	75	75	100	100			
11	37	75	75	100	100			
12	37	75	75	100				
13	37	75	75	100				
14	37	75	100	100				
15	50	75	100	100				
16	50	75	100	100				

COMPARISON OF TRANSFORMER SIZING (NEW BRUNSWICK)

N.B.E.P.C. *OTTAWA HYDRO*

NUMBER OF ELECTRIC HEAT CUSTOMERS 15 kW

NUMBER OF REGULAR	0	1	2	3	4	5	6	7
0	-	25 *25*	37 *25*	50 *37*	75 *50*	75 *75*	100 *75*	100 *75*
1	10 *25*	25 *25*	37 *37*	50 *50*	75 *75*	75 *75*	100 *75*	100 *100*
2	10 *25*	25 *25*	37 *37*	50 *50*	75 *75*	100 *75*	100 *100*	100 *100*
3	15 *25*	25 *37*	37 *50*	50 *50*	75 *75*	100 *75*	100 *100*	100 *100*
4	15 *25*	37 *37*	37 *50*	50 *75*	75 *75*	100 *75*	100 *100*	100 *100*
5	25 *25*	37 *37*	50 *50*	75 *75*	75 *75*	100 *75*	100 *100*	
6	25 *25*	37 *37*	50 *50*	75 *75*	75 *75*	100 *100*	100 *100*	
7	25 *25*	37 *37*	50 *50*	75 *75*	75 *75*	100 *100*		
8	25 *25*	37 *50*	50 *75*	75 *75*	75 *75*			
9	25 *37*	37 *50*	50 *75*	75 *75*				
10	37 *37*	50 *50*	75 *75*					

NUMBER OF ELECTRIC HEAT CUSTOMERS 20 kW

NUMBER OF REGULAR	0	1	2	3	4	5	6	7
0	-	25 *25*	37 *37*	75 *50*	75 *75*	100 *75*	100 *75*	
1	10 *25*	25 *25*	37 *37*	75 *50*	75 *75*	100 *75*	100 *100*	
2	10 *25*	25 *37*	50 *50*	75 *75*	75 *75*	100 *100*	100 *100*	
3	15 *25*	37 *37*	50 *50*	75 *75*	75 *75*	100 *100*		
4	15 *25*	37 *37*	50 *50*	75 *75*	100 *75*	100 *100*		
5	25 *25*	37 *37*	50 *50*	75 *75*	100 *75*	100 *100*		
6	25 *25*	37 *50*	50 *75*	75 *75*	100 *100*	100 *100*		
7	25 *25*	37 *50*	75 *75*	75 *75*	100 *100*	100 *100*		
8	25 *37*	37 *50*	75 *75*	75 *75*	100 *100*			
9	25 *37*	50 *50*	75 *75*	75 *75*				
10	37 *37*	50 *50*	75 *75*	75 *75*				

COMPARISON OF TRANSFORMER SIZING
OTTAWA HYDRO (OTT), NEW BRUNSWICK (NB), ONTARIO HYDRO (ONT)
1500 FT.^{2} ± HOUSE

-------ONT. HYDRO HIGH, ——— OTTAWA HYDRO HIGH

NUMBER OF OIL HEAT CUSTOMERS WITH ELECTRIC HOT WATER		NUMBER OF ELECTRIC HEAT CUSTOMERS							
		0	1	2	3	4	5	6	7
0	OTT	-	25	37.5	37.5	50	75	75	75
	NB	-	25	37.5	50	75	75	100	100
	ONT		25	25	37.5	50	50	75	75
1	OTT	-	25	37.5	50	75	75	75	100
	NB	10	25	37.5	50	75	75	100	100
	ONT	10	25	37.5	50	50	75	75	75
2	OTT	-	25	37.5	50	75	75	100	100
	NB	10	25	37.5	50	75	100	100	100
	ONT	10	25	37.5	50	50	75	75	75
3	OTT	-	25	37.5	50	75	75	100	100
	NB	15	25	37.5	50	75	100	100	100
	ONT	25	25	37.5	50	50	75	75	75
4	OTT	25	37.5	50	50	75	75	100	100
	NB	15	37.5	37.5	50	75	100	100	100
	ONT	25	37.5	50	50	75	75	75	100
5	OTT	25	37.5	50	75	75	75	100	100
	NB	25	37.5	50	75	75	100	100	-
	ONT	25	37.5	50	50	75	75	75	100
6	OTT	25	37.5	50	75	75	100	100	100
	NB	25	37.5	50	75	75	100	100	-
	ONT	37.5	50	50	50	75	75	100	100
7	OTT	25	37.5	50	75	75	100	100	100
	NB	25	37.5	50	75	75	100	-	-
	ONT	37.5	50	50	75	75	75	100	100
8	OTT	25	50	50	75	75	100	100	100
	NB	25	37.5	50	75	75	-	-	-
	ONT	37.5	50	50	75	75	75	100	100
9	OTT	37.5	50	75	75	75	100	100	100
	NB	25	37.5	50	75		-	-	-
	ONT	50	50	50	75	75	100	100	100
10	OTT	37.5	50	75	75	100	100	-	-
	NB	37.5	50	75			-	-	-
	ONT	50	50	75	75	75	100	100	100

COMPARISON OF TRANSFORMER SIZING
OTTAWA HYDRO (OTT), NEW BRUNSWICK (NB), ONTARIO HYDRO (ONT)
2000 FT.^{2} ± HOUSE

-------ONT. HYDRO HIGH, ——— OTTAWA HYDRO HIGH

NUMBER OF OIL HEATED CUSTOMERS WITH ELECTRIC HOT WATER		NUMBER OF ELECTRIC HEAT CUSTOMERS							
		0	1	2	3	4	5	6	7
0	OTT	-	25	37.5	50	75	75	75	100
	NB	-	25	37.5	75	75	100	100	-
	ONT	-	25	37.5	50	50	75	75	75
1	OTT	-	25	37.5	50	75	75	100	100
	NB	10	25	37.5	75	75	100	100	-
	ONT	10	25	37.5	50	50	75	75	100
2	OTT	-	37.5	50	75	75	100	100	100
	NB	10	25	50	75	75	100	100	-
	ONT	10	25	50	50	75	75	75	100
3	OTT	-	37.5	50	75	75	100	100	100
	NB	15	37.5	50	75	75	100	-	-
	ONT	25	37.5	50	50	75	75	75	100
4	OTT	25	37.5	50	75	75	100	100	-
	NB	15	37.5	50	75	100	100	-	-
	ONT	25	37.5	50	50	75	75	100	100
5	OTT	25	37.5	50	75	75	100	100	-
	NB	25	37.5	50	75	100	100	-	-
	ONT	25	37.5	50	50	75	75	100	100
6	OTT	25	50	75	75	100	100	100	-
	NB	25	37.5	50	75	100	100	-	-
	ONT	37.5	50	50	75	75	75	100	100
7	OTT	25	50	75	75	100	100	100	-
	NB	25	37.5	75	75	100	100	-	
	ONT	37.5	50	50	75	75	100	100	100
8	OTT	37.5	50	75	75	100	100	-	-
	NB	25	37.5	75	75	100	-	-	-
	ONT	50	50	75	75	75	100	100	100
9	OTT	37.5	50	75	75	100	100	-	-
	NB	25	50	75	75	-	-	-	-
	ONT	50	50	75	75	100	100	100	
10	OTT	37.5	50	75	75	100	100	-	-
	NB	37.5	50	75	75	-	-	-	-
	ONT	50	50	75	75	100	100	100	

DISTRIBUTION

Dr. D. Mills	Director of Research
Mr. W. Hassan	Municipal Electrical Association
Mr. D. Brook	Kitchener-Wilmot HEC
Mr. G. Eamer	Brockville PUC
Mr. A.P. Starck	Pickering Hydro
Mr. C.F. Kropp	Ottawa Hydro
Mr. R.L. Wilde	RLW Engineering Ltd
Dr. J. Carr	Acres International Limited
Mr. G.W. Ryckman	Dist Systems, U5A2
Mr. L.V.McCall	Dist Systems, U5A3
Mr. B.E. Gill	Dist Systems, U5A6
Mr. J.R. Bailey	Dist Systems, U6A1
Mr. R.G. Bird	Dist Systems, U6A5
Mr. W.T. Miller	Dist Systems, U5A4
Mr. D.M. Anderson	Dist Systems, U6A1
Mr. A.F. Baljet	Electrical Research
Mr. J.N. Edgar	Electrical Research
Mr. J. Kortschinski	Electrical Research
Mr. S. Cress (5)	Electrical Research

Public Reference Center
Editorial Section (2)
Office Copies (3)
Extra Copies (3)